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LAND-USE PLANNING *

PRIOR to the war of 1914-1918 land utilization all over the world was haphazard. Since then physical and economic events have occurred which have demonstrated in no uncertain way the dangers of leaving land utilization to be determined by the interplay of transient economic forces. Among the more unpleaseant results have been unbalanced production—avoidable surpluses and deficits existing side by side—and soil deterioration on a scale that has sometimes threatened the existence of empires. The results have been ubiquitous in their incidence and have produced a widespread conviction that lasting social and political stability requires a balanced utilization of, and production from, the land of the whole world or of whatever economic units it finally differentiates into. This means *planned* land use and there are signs that several of the great nations of the world intend to adopt it as a part of national policy.

Land-use planning is primarily a political matter. It obviously cannot be carried out in a politically undeveloped community, and its objective is bound to be political, i.e., use of the land is planned to promote the welfare of a definite type of society. The Americans in particular have thought and written a lot about land-use planning. Its objective in the U. S. is frequently stated to be the use of the land for the greatest good of the greatest number, as determined by the people themselves—an objective closely according with the popular democratic ideals of the country. Before the war the Germans had already to a large extent executed a land-use plan designed to give self-sufficiency to a military state, the Russians were putting into operation a plan which would allow socialist, collective agriculture to function smoothly over the whole Soviet Union, and in several British colonies land-use plans were under consideration with a view to securing the greatest good to the people —as defined by a distant administration in London.

All these are countries in which a political equilibrium with the environment has not yet been attained. In older, politically mature countries the vogue of national land-use planning has not yet appeared, even though in some of them the need for such planning, judged by the present efficiency of land-use, is as great as

* Reprinted from *Soils and Fertilizers*, V, No. 4, 1942.

anywhere. One is drawn towards the conclusion that land-use planning is symptomatic of a disharmony between the existing political set-up of a country and produce of its land, somewhat analogous to the ecological instability which characterizes the pre-climax stages of plant succession.

The dependence of the type of land-use plan on the political complexion of the planners shows that there is no ideal way of using land. A prerequisite to any plan is some system of classification of the material to be planned, and it follows therefore that for practical purposes a purely objective system of land classification is not feasible. Probably the most objective basis for a system of land classification would be the genetic soil type which reflects fully and concisely the inherent qualities of the environment. The Russians, indeed, very largely base their agricultural land classification on the genetic soil classification. In general they plan by selecting the most suitable combination of soil and climate for each crop or type of agriculture, and if present economic and social conditions are unfavourable to the marketing or disposal of the selected crop, these are modified rather than the projected land use. The Germans, who are a little less sure than the Russians of the political framework of Utopia, classify land mainly according to soil properties and past land use, while the democratic Americans, although regarding soil type as a valuable basic index to land type, consider that economic or other "transient" factors may (and as often as not will) determine land-use class independently of soil type. In some places existing markets, in others the financial state of the community or some social peculiarity may be the predominant factor in a practical land classification. The Russians and Germans plan for predetermined forms of society, the Americans so that trends in land-use should conform with trends in social evolution—without making much attempt to define the latter.

The more definite the political goal the simpler is the problem of land classification and the more closely is it identified with that of soil classification. In countries with democratic traditions there is likely to be considerable divergence between soil classification and land classification, and the latter tends to develop into a highly complicated argument between soil scientists, agriculturists, geologists and political economists. Indeed, judging from published statements it is doubtful whether many Americans agricultural-land classifiers know how, why or what they are classifying. In colonial territories the problem is rather simpler since the dominant power can fix its own political goal, but up to the present colonial land classification has not progressed far enough to enable us to pronounce on its value as an instrument in planning. The matter is of some urgency in view of the rapid deterioration of much colonial land through past and present misuse, but it is clearly desirable that the goal of planning be defined with some precision before any system of land classification is adopted for or adapted to the colonies.

The same is true generally. It is impossible to plan land-use without—perhaps sub-conciously—planning society at the same time. The soil surveyor, whose services are indispensable to the land-use planner, need not, however, be an expert sociologist, but he should have a clear appreciation not only of the influence of land usage on social development, but also of how the structure of society affects the practical classification of land.

PLANT OILS AS INSECTICIDES

A Technical Bulletin, No. 801, has been issued by the United States Department of Agriculture (Washington, D.C.) entitled "Insecticidal Efficiency of some Oils of Plant Origin" by A. W. Cressman and Lynn H. Dawsey. Oils may be classified into three groups according to origin—plant, animal and mineral. Oils of the last type, especially petroleum oils, have found wide utility in insect control, most of the American investigations being based on this class. The trouble with these oils has been the injurious effects which may be produced on the plants to be protected. For foliage sprays, plant oils would reduce this danger. The authors compared the insecticidal efficiencies of a number of oils of plant origin with that of a refined petroleum oil. Emulsions were prepared by mixing these oils with ground bone glue in a high-speed drink mixer. Tests, for which the Bulletin must be consulted, were carried out on Mexican mealy bugs reared on potted chrysanthemum plants in the greenhouse, which were sprayed in the laboratory. Mature females and eggs of the willow scurfy scale on willow twigs and fruit-tree leaf roller eggs on apple twigs were collected in the field and brought to the laboratory for treatment. Oils experimented with were crude corn oil, crude cotton-seed and pea-nut oils and their refined stages, also orange and pine oils. It is stated that "Although vegetable oils are generally higher priced than petroleum oils, they possess superior solvent action for certain organic insecticides, and may find new uses because of this property."—(*Nature*, No. 3801, 1942, p. 294.)

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THE EFFECT OF AGE OF FIELD ON CACAO YIELDS IN GRENADA COMPARED WITH THE MONTSERRAT DISTRICT OF TRINIDAD

BY
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An analysis of the effect of manurial status, soil type, and age of field in Grenada has recently been published (1); at the time there was no similar analysis of other cacao growing districts with which to make comparisons. It is thought desirable, therefore, to analyse data for Trinidad in a similar manner to determine whether they confirm or contradict the Grenada findings.

The Data

Data relating to field yields and populations have been collected in Trinidad since 1931. The intention has, however, never been to obtain a comprehensive picture of the whole island but rather to determine the more fundamental factors affecting field yields. It has only been possible in one district (Montserrat) to examine a sufficient number of fields on each soil type for the data to be suitable for comparative analysis. It is proposed, therefore, to utilise the data relating to Montserrat as published by Shephard (2).

Twenty fields are available for analysis and have been arranged according to soil type in Table I. It can be immediately seen that there is a very wide difference in yields on Brasso Clay (.69 lbs. per picket) and the other three types (1.81 lbs.) and that the differences between the three more productive types (especially in view of the variation in average field age) is not very great. It appears from the Table that any adjustment that is to be made for soil type must be as between (i) Chocolate, Brasso Sand and Alluvial Soils combined (Good Soils) and (ii) Brasso Clay.

Because of the striking difference between these two soil groups it was thought necessary in the first place to analyse the age effect for the groups separately. The separate analyses insure that a difference in the effect of age between the groups which is to be expected from Table I would not be overlooked. The dependent variables were the same as for Grenada except that yield per acre was omitted; the variables are :—

(i) Yield per picket.
(ii) Yield per tree.
(iii) Yield per bearer.
(iv) Yield of original trees.
(v) Percentage of blank pickets.
(vi) Percentage of non-bearing trees.
(vii) Percentage of original trees.

All yields except (iv) are averages calculated from the total field yields; the yield of original trees (iv) is the average from this type of tree only.

Comparison between the Two Islands

Very striking differences were found in the effect of age of field between the two soil groups. Broadly speaking no effect (except for (vii), the percentage of original trees) was observed on the Good Soils whereas a very marked effect was observed on the Brasso Clay (for the significance of the various regressions, see the Appendix). It is therefore unsound to use the whole Trinidad data (adjusting for soil) for comparison with Grenada except in respect of the percentage of original trees.

Table I

Montserrat Fields grouped by Soil Type

Soil Type *	Age of field	Yield/ picket (lbs)	Yield/ bearer (lbs)
1. Chocolate ...	45	1.24	1.76
2. ,, ...	48	2.25	2.30
3. ,, ...	50	1.89	2.30
4. ,, ...	60	2.14	2.58
5. ,, ...	70	1.99	2.32
Average of Chocolate Soil	55	1.90	2.25
6. Brasso Sand ...	18	2.22	2.76
7. ,, ...	36	1.60	1.99
8. ,, ...	65	2.04	2.50
9. ,, ...	71	1.47	1.94
Average of Brasso Sand	48	1.83	2.30
10. Alluvial ...	49	1.50	1.82
11. ,, ...	76	2.07	2.51
12. ,, ...	76	1.37	1.70
Average of Alluvial Soil	67	1.65	2.01
Average Chocolate, Brasso Sand and Alluvial	56	1.81	2.21
13. Brasso Clay ...	20	1.40	1.82
14. ,, ,, ...	20	.90	1.52
15. ,, ,, ...	25	.84	1.30
16. ,, ,, ...	30	.75	1.37
17. ,, ,, ...	40	.54	1.21
18. ,, ,, ...	40	.59	1.09
19. ,, ,, ...	45	.25	.66
20. ,, ,,	45	.28	.75
Average Brasso Clay	33	.69	1.22

* The most recent nomenclature of these soil types is as follows :—

Chocolate ...Montserrat Clay Silt (A)
Brasso Sand...Montserrat Loam (B)
Alluvial ...L'Ebranche Clay Silt
Brasso Clay ...Ecclesville Clay

The trends in the percentage of original trees on the two Trinidad soil groups are shown in Figure 1; the casualty rate of trees is evidently similar on the two soil groups but is delayed by about 15 years on the Good Soils. The trend adjusted for and thus combining the two soil

groups is compared with the Grenada curve in Figure 2. It is evident that the casualty rate is lower in Grenada than in the Montserrat district of Trinidad and that a big difference occurs in the percentage of original trees surviving in old fields of the two regions. The reasons for this difference are twofold: (i) immortel shade trees in old Trinidad fields cause considerable casualties among the cacao trees on good soils; and (ii) the supplying of unhealthy, old and damaged trees is carried on more regularly in Trinidad than in Grenada.

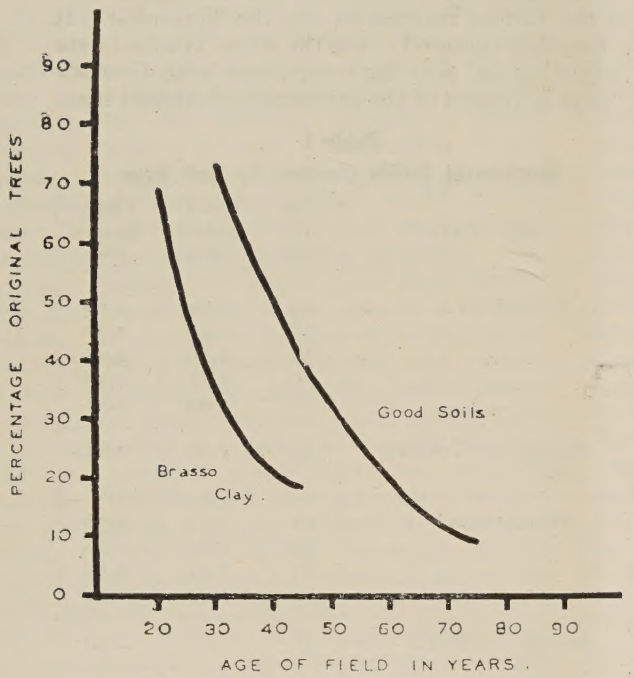

FIG. 1—Effect of field age on percentage of original trees on Brasso clay and good soils.

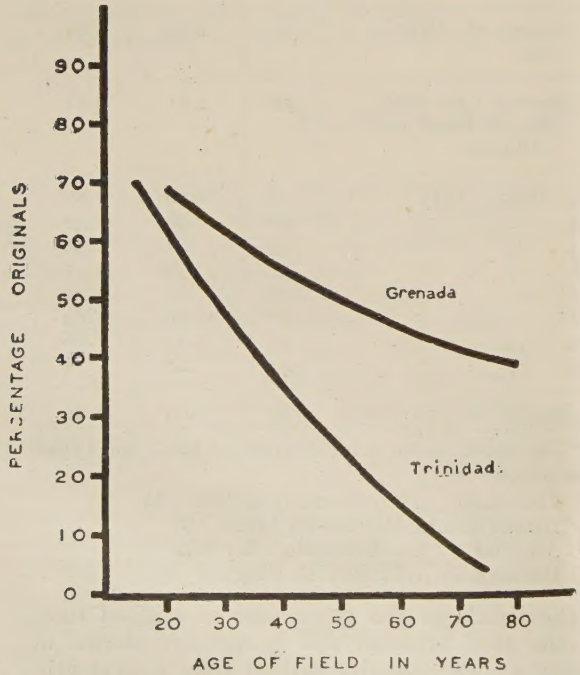

FIG. 2—Effect of field age on percentage of original trees in Trinidad and Grenada.

It must be admitted that with the data available it is not justifiable to combine the two soil groups in Trinidad for other comparisons with Grenada: the effect of age of field is of such little importance on Good Soils and of such great importance on Brasso Clay that the two groups cannot be averaged. It is not necessarily implied that with more numerous and extensive data for Good Soils no age effect would be found; for instance, a bigger representation of younger fields might entirely change the picture. But apart from the evidence that on Good Soils age of field has a small effect on yields, nothing more is to be learned from the data for this group.

Comparison of Brasso Clay with Grenada

It might be assumed that there was little value in comparing the Grenada results referring to average soils in that island with Brasso Clay, one of the worst cacao soils in Trinidad. Such an assumption would be sound but for the fact that the comparison reveals a most striking contrast between the two. Figures 3 and 4 illustrate the trends in yields and populations on Brasso Clay and show all evidence of a process of field exhaustion on this soil from at most 20 *years field age* onwards. All yields decline sharply; the percentage of original trees also falls rapidly, while the percentage of non-bearing trees increases with increased field age.

The very marked contrast of these trends with those of Grenada is shown in Figures 5, 6 and 7. There is no doubt that in Grenada the decline of fields does not commence until about 60 years of field age, whereas on Brasso Clay there is every evidence that the decline is already well in progress when the field is only twenty years of age.

It is interesting to note that in spite of the difference in trends the yields do not differ greatly at 20 years field age. A striking contrast is shown in Figure 7; the percentage of non-bearing trees in Grenada remains on the average at about 5 per cent. irrespective of field age; on Brasso Clay these trees increase from about 25 to 55 per cent. of the total pickets over a period of only 25 years. The sharp declines in yields on Brasso Clay in fact are not so much due to trees dying out as to trees for some reason becoming unproductive.

Possible Causes for Differences

It should be emphasised that the fields both in Grenada and on Brasso Clay were all under commercial cultivation at the time the data were collected. None of the Brasso Clay fields was abandoned and none in Grenada was given uncommercially lavish treatment in respect of manure or cultivation. It is therefore of importance in itself that the commercial production of cacao can be carried on under conditions varying to such an extent to give this contrast in results.

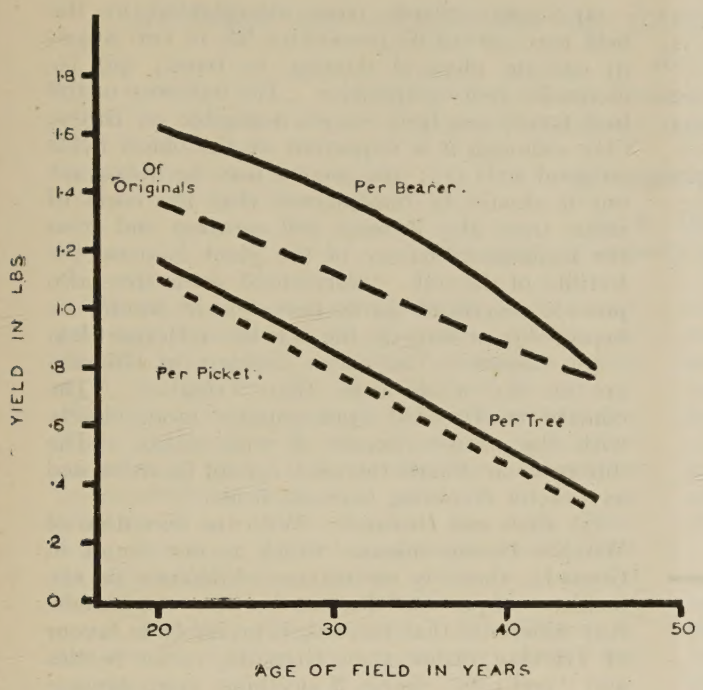

FIG. 3—Effect of field age on yields on Brasso clay.

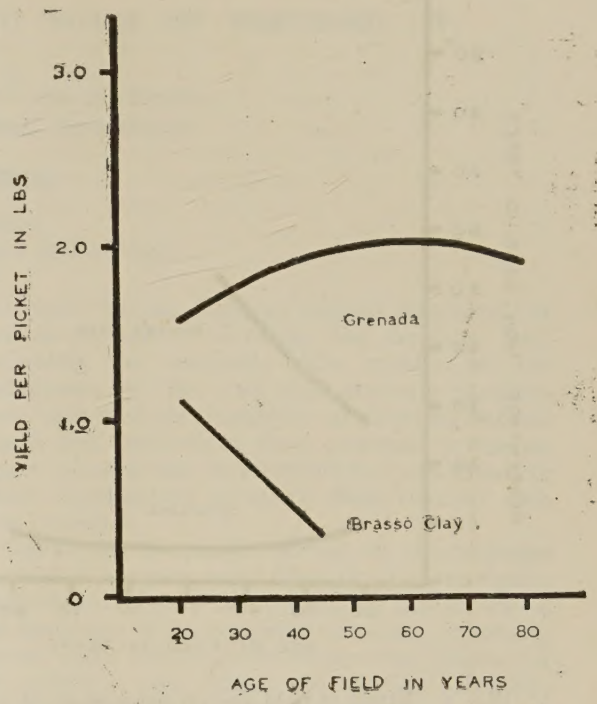

FIG. 5—Effect of field age on yield per picket. (Grenada adjusted for soil type and manuring)

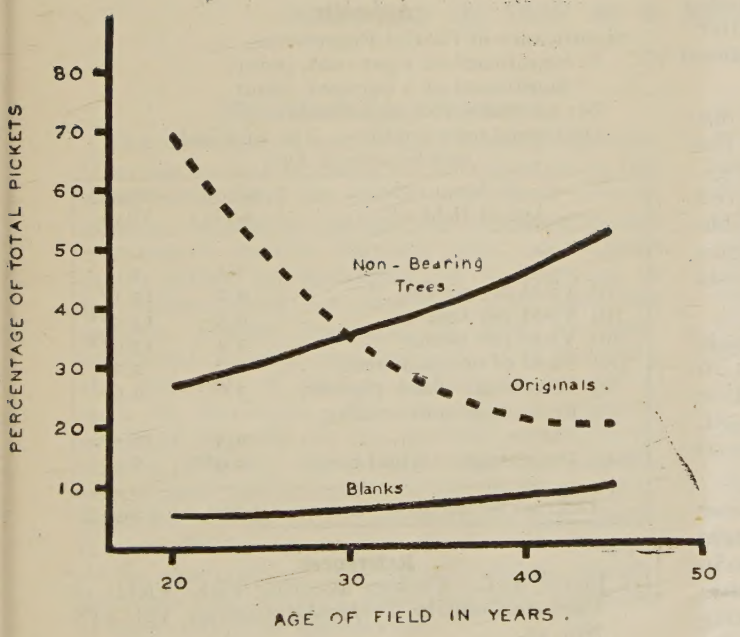

FIG. 4—Effect of field age on populations on Brasso clay.

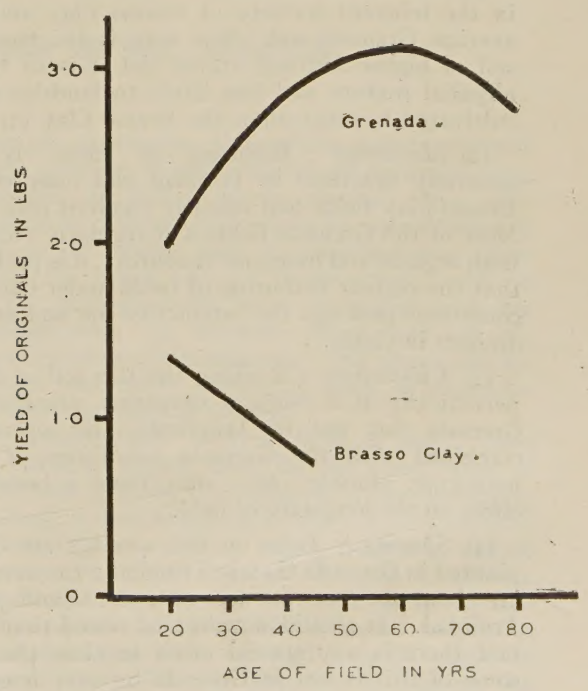

FIG. 6—Effect of field age on yield of original trees. (Grenada adjusted for soil type and manuring)

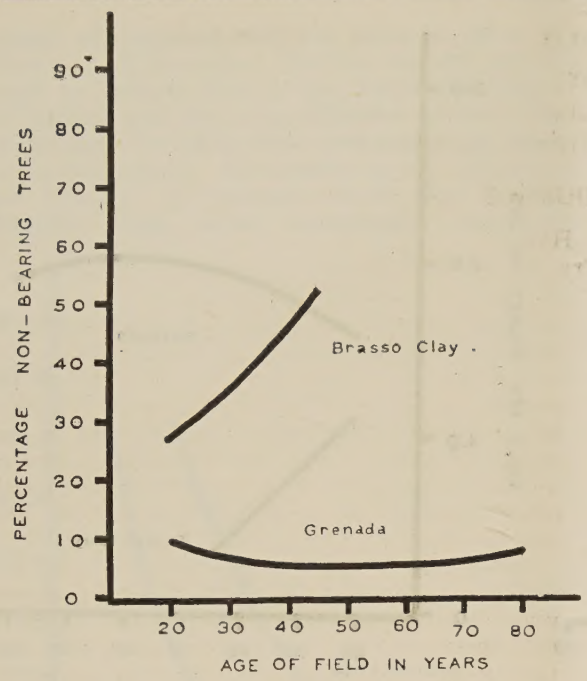

FIG. 7—Effect of field age on percentage of non-bearing trees. (Grenada adjusted for soil type and manuring).

It is impossible without further evidence to assess the relative importance of the many factors contributing to this difference but it may be instructive to tabulate some of the differences between the two cultivations.

(1) *Soil:* There is undoubtedly a wide difference in the inherent fertility of Brasso Clay and the average Grenada soil. Not only is the Grenada soil of higher nutrient status but it is of better physical texture and less liable to landslip when cultivated in cacao than the Brasso Clay (3).

(2) *Manuring:* Manuring of cacao is not generally practised in Trinidad and none of the Brasso Clay fields had recently received dressings. Most of the Grenada fields had regularly received both organic and inorganic manures; it is probable that the regular manuring of fields under Grenada conditions prolongs the productive life and arrests declines in yields.

(3) *Cultivation:* Forking the top soil of fields periodically is a cultural operation practised in Grenada but not in Trinidad. This operation combined with the Grenada conditions of soil, manuring, climate, &c., may have a beneficial effect on the longevity of field.

(4) *Spacing:* Trees on the average are closer planted in Grenada than in Trinidad; the averages are about 400 trees per acre in Grenada and 300 in Trinidad. It should however be noted that if in fact there is any special merit in close planting some of this is lost in Grenada by very irregular spacing throughout most fields. In many fields, individual trees may be as close as 6 feet from each other (1,200 per acre) with correspondingly wider spacing between other individuals.

(5) *Shade:* Shade trees interplanted in the field may curtail its productive life in two ways: (i) causing physical damage to trees; (ii) by increasing root competition. The influence of the first factor has been shown negligible on Brasso Clay although it is important on the oldest fields on good soils (2); the second may be important but it should be remembered that the roots of shade trees also increase soil aeration and from the leguminous nature of the plant increase the fertility of the soil. Interplanted shade trees also provide overhead protection which would be expected to prolong the life of fields on Brasso Clay.

(6) *Climate:* The cacao districts of Grenada are on the whole drier than Trinidad. The climate in Trinidad approximates more closely with the native climate of wild cacao. The difference in climate therefore cannot be accounted as a factor favouring Grenada fields.

(7) *Pests and Diseases:* With the exception of Witches Broom disease, which is not found in Grenada, there is no marked difference in the incidence of pest and diseases between the islands. Any difference that there is, is probably in favour of Trinidad rather than Grenada, cacao beetles and "pod rots" doing, if anything, more damage in the latter island. At the time the Trinidad data were collected (1934-36) Witches Broom did little damage to the pods on the fields examined and certainly did not affect the older fields more severely than the younger.

It can be seen from this list that all differences are not in favour of longevity in Grenada and rapid deterioration on Brasso Clay. It is therefore even more noteworthy that cacao is commercially cultivated with such strikingly different results.

Appendix

Significance of Partial Regressions.
** Significant at 1 per cent. point.
* Significant at 5 per cent. point.
No asterisk—Not significant.
(Independent variables: Age of Field, and Square of Age)

F VALUES Age of field on:	Good Soils	Brasso Clay
	1:	1:
(i) Yield per picket ...	0.2	12.1*
(ii) Yield per tree	0.5	13.5**
(iii) Yield per bearer ...	0.4	13.9**
(iv) Yield of original trees ...	0.7	2.2
(v) Percentage blank pickets...	3.6	0.6
(vi) Percentage non-bearing trees	0.5	10.7*
(vii) Percentage original trees	9.9**	8.9*
Degrees of freedom ...	9 and 2	5 and 2

References

(1) JOLLY, A. L.—Factors affecting Field Yields of Cacao in Grenada. *Tropical Agriculture*, Vol. XIX No. 12.

(2) SHEPHARD, C. Y.—Cacao Industry of Trinidad. Series III and IV. *Government Printing Office, Port-of-Spain*, 1937.

(3) HARDY, F. H.—*et alia*—Cacao Soils of Grenada *Government Printing Office, Port-of-Spain*, 1932.

STUDIES ON AERATION OF CACAO SOILS IN TRINIDAD (IV)

BY

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INTRODUCTION

BY F. HARDY
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The series of studies (of which this is the fourth and last) on the aeration and water relations of certain cacao soils in Trinidad, undertaken during 1938 to 1940 by Dr. H. Vine and Mr. H. A. Thompson, former post-graduate students of the Imperial College of Tropical Agriculture, included an attempt by Dr. Vine to measure soil aeration by determining the rate of corrosion of pieces of iron buried at various depths. The main object was to evolve a simple rapid method that might be applicable on a broad scale in ecological investigations of growth conditions, not only of cacao, but also of other crops. As will be seen, the results obtained are encouraging, though not conclusive.

Since Dr. Vine and Mr. Thompson left the College, the work they started has been continued with the limited staff and resources available, and it is proposed to publish the results as they emerge. It seems to us that the chief need in agricultural research is means for quantitatively estimating fluctuating water supply and air supply in soils growing different crops, so that the effects of soil-types, having different natural structures, as well as the effects of tillage and drainage, may accurately be assessed. The results of the endeavours of the two post-graduate students have indicated the feasibility of applying several simple field methods to these ecological problems, and it is hoped that their publication will stimulate other investigators to apply them to their own crop problems.

Concerning the present article on the corrosion method, it may be noted that Dr. Vine's original unpublished dissertation contains a full review of the literature of the corrosion of metals, involving twenty-eight references to outstanding papers on the subject, from which the section following, headed "Theoretical Considerations", has been abstracted. The article itself has been preceded in publication by another one submitted by Dr. Vine to the Editor of *Soil Science*; this is entitled "Dependence of the Rate of Corrosion of Buried Iron on the Oxygen Supply of the Soil", and it was issued as part of the September, 1942, number of that Journal, Vol. LIV, pages 159-176.

PART IV

CORROSION OF IRON AS A MEASURE OF SOIL AERATION

BY H. VINE

Theoretical Considerations

The corrosion of iron is an electrolytic process. Over the surface of contact with a solution or film of moisture there are anodic points and cathodic points. At anodic points, iron atoms pass into solution as positive (ferrous) ions; at cathodic points either (*a*) hydrogen gas is liberated, or (*b*) hydroxyl-ions are produced from molecular oxygen. During corrosion of iron by soils, additional cathodic reactions may occur, involving the reduction of oxidised substances or entities such as ferric-ion. The amount of corrosion produced depends on the quantity of electricity passing between the anodic and the cathodic points, and this in turn depends on the potential difference set up by the electrolytic action, which is controlled by the concentration or rate of supply of the reactants at the cathodic points, namely, hydrogen-ions, oxygen molecules and ferric-ions or other reducible substances.

The rate of corrosion of iron in pure distilled water and in solutions of unhydrolised pure salts has been found to be proportional to the amount of oxygen in solution, though it is greatly affected by the presence of acids, that is, of hydrogen-ions. Corrosion in water whose reaction has been adjusted to different pH values by the addition of acids or of alkalies may be classified into three zones: (i) below pH 4.3 (hydrochloric acid) or pH 5.4 (carbonic acid), when hydrogen evolution predominates; (ii) between pH 5 and pH 10, when oxidation predominates; (iii) above pH 10, when a protective coating of oxide accumulates and corrosion rapidly ceases.

In consideration of these facts, it would seem reasonable to expect that, for the usual range of fertile soils (neither too highly acid nor too highly alkaline), a determination of the rate of corrosion of buried pieces of iron might furnish a simple measure of the degree of soil aeration. Accordingly, experiments were carried out by the author at selected sites within cacao estates in Trinidad whose soils covered a wide range of physical types, for the purposes of testing the method, and of procuring data for comparison with previous results obtained in other soil aeration investigations.

Experimental Work

Pointed strips or flat spikes of commercial mild steel, 6 ins. by 1 inch by 1/8 inch thick, were painted with a two-inch band of varnish at the broad end, stamped with serial numbers, and thoroughly cleaned with dilute hydrochloric acid and water. They were then dried in a desiccator and weighed. The average weight was 90g. Those intended for deep burial were fitted with wooden handles (broom sticks) fixed in slots by means of wooden pegs driven into holes bored through the handles and the spikes.

EXPERIMENT I

(*a*) *Object and method*:—The object of this experiment was to compare the corrosiveness of certain cacao soils, comprising sandy and clayey types, under wet conditions. Since it was found difficult to measure the oxygen content of the more clayey soils directly by gas analysis methods applied during the wet season (*see* Part II), a simple indirect method, such as iron corrosion affords, should prove especially useful.

The experiment was carried out during September and part of November, 1939, at the height of the rainy season, at six sites in cacao fields offering varied soil conditions. Weighed iron spikes were exposed in sets of three at four depths at each site, namely, 0-4, 4-8, 8-12 and 24-28 inches. The period of contact in each case was six weeks. The twelve spikes used at each site were inserted in the ground within an area about two yards square.

(*b*) *Description of sites and soils*:

(1) *Ortinola Estate*, Maracas Valley, Northern Range. Site on a steep hillside between scattered boulders. Soil; dark-brown, porous, crumbly, stony sand, uniform to three feet. Productivity to cacao, very high.

(2) *Torrecilla Estate*, Arima Valley, Northern Range. Site on an alluvial terrace. Soil; dark-brown, crumbly sand, compact below 4 inches depth, gravelly below 24 inches. Productivity to cacao, fairly high.

(3) *River Estate*, Diego Martin, Northern Range (previously described in Parts I and II). Site; Field 25 on an alluvial flat. Soil; uniform, compact, fine loamy-sand. Productivity to cacao, fairly high.

(4) *L'Agnesia Estate*, Cumuto, Northern Plain. Site on a gentle hill slope. Soil; sandy in surface layer, impervious sandy-clay below; yellowish to 12 inches, red-mottled on grey below. Productivity, low.

(5) *San Louis Estate*, Guaico, Sangre Grande District, Northern Plain. Site on a low-lying, badly-drained, alluvial flat. Soil; compact clay in surface layer; cubical nut structure; yellow and yellow-mottled on blue-grey clay below. Productivity low.

(6) *Las Hermanas Estate*, San Rafael, Northern Plain (previously described in Part II). Site on a low-lying, badly-drained alluvial flat. Soil; humic and crumbly in surface inch, but contaminated with thrown-up drain-bottom soil; yellow, yellow-mottled on blue-grey and blue impervious clay below. Productivity low.

Table I presents relevant laboratory data for the soils at the six sites.

Note.—(i) The texture ranges from sandy (Nos. 1, 2) to loamy (Nos. 3, 4), to clayey (Nos. 5, 6).

(ii) In some cases the reaction value approximates pH 4.3, which may be regarded as marking the stage of acidity when evolution of hydrogen-gas is likely to occur and corrosion increases rapidly because of cathodic action not involving oxygen. The most highly acid layer is the surface 4-ins. layer at the Las Hermanas clay site (No. 6; pH 4.4), nor is the second 4-ins. layer much less acid (pH 4.7). Highly acid soil also occurs at the San Louis clay site (No. 5; pH 4.9), and markedly acid conditions occur at the two loamy sites (No. 4; pH 5.1; No. 3; pH 5.7), but the soils at the two sandy sites are only slightly acid or nearly neutral (No. 2; pH 6.3; No. 1; pH 6.8), though the lowest layer at the Torrecilla sandy site is highly acid (No. 2; pH 4.9).

(*c*) *Experimental results*:—The mean corrosion values for the sets of three determinations, expressed as loss in weight of one iron spike during a 6 weeks' exposure, for each depth at each site, are given in Table II, condensed and summarised from the full tabulated data.

Table I

Laboratory Data for Soils at Six Sites

Site	0-4 ins.		4-8 ins.		8-12 ins.		24-28 ins.	
	Sand* %	pH†	Sand %	pH	Sand %	pH	Sand %	pH
1. Ortinola	48	7.1	52	7.1	54	6.6	55	5.9
2. Torrecilla	(60)	6.7	(60)	6.2	(60)	5.9	(60)	4.9
3. River	42	5.8	44	5.5	41	5.7	46	5.9
4. L'Agnesia ...	44	5.4	39	5.1	21	5.0	23	4.8
5. San Louis ...	6	4.9	5	4.9	6	4.8	5	5.1
6. Las Hermanas ...	4	4.4	2	4.7	3	4.8	3	5.1

*Sand; Coarse and fine sand, 2.0-0.02 mm.

†pH; Glass electrode; suspension 1 part fresh soil to 3 parts water.

Table II

Results of Corrosion Tests at Six Different Sites

(Six weeks' exposure)

Site	0-4 ins.	4-8 ins.	8-12 ins.	24-28 ins.	Means
	Loss in weight of one iron spike : means of three (centigrams)				
1. Ortinola	58 (72)	43 (53)	56 (69)	33 (41)	48 (100)
2. Torrecilla	68 (84)	51 (63)	31 (38)	17 (21)	42 (88)
3. River	55 (68)	50 (62)	37 (46)	15 (19)	39 (81)
4. L'Agnesia	47 (58)	56 (69)	24 (30)	16 (20)	36 (75)
5. San Louis	36 (44)	27 (33)	29 (36)	17 (21)	27 (56)
6. Las Hermanas ...	81 (100)	65 (80)	20 (25)	15 (19)	45 (94)
Means	58 (100)	48 (83)	33 (57)	19 (33)	40

Note.—Figures in brackets are percentages of largest value for comparable series of values.

The individual values in the sets of three results whose means are given in the table show considerable variability, but the differences between their means demonstrate large variations in soil conditions between the six sites and between the four depths at each site. They also reveal distinct differences at corresponding depths at the different sites. The significance of the numerical differences has been tested by the analysis of variance method, and standard errors have been calculated for all the mean values. The statistics are not here reproduced, but they are given in full in the original dissertation.

None of the soils contains appreciable amounts of soluble salts; electrical conductivity measurements made on water extracts of the soils gave low values, ranging from 60 to 15 units. Hence the presence of salts need not be invoked to explain the corrosion results.

(*d*) *Conclusions* :—The statistical analyses prove that there are real differences in amount of corrosion at the different depths and at the different sites; the observed differences are thus not merely due to chance nor to experimental error.

(i) For 0-4 ins. depth, the rate of corrosion was significantly greater at the Las Hermanas site than at any of the other sites except Torrecilla, and significantly least at the San Louis site.

(ii) For the 4-8 ins. depth, the rate was also significantly least at the San Louis site, the values for the other sites being about equal.

(iii) For the 8-12 ins. depth, greatest corrosion occurred at Ortinola and least at L'Agnesia and Las Hermanas, which each gave significantly smaller values than the River Estate site.

(iv) For the 24-28 ins. depth, corrosion at Ortinola was much greater than at any other site; the rest all showed relatively low values.

The marked decrease in soil-corrosiveness with increasing depth can only be attributed to a corresponding decrease in oxygen supply. This finding in the case of the River Estate soil whose aeration was tested by other means is exactly what would be expected from the earlier results of porosity and soil-gas analytical studies. Thus it was shown that, at about the same time as the corrosion experiments were being carried out, the pore-space of the River Estate soil was nearly filled with water below the 24-inches depth (Part I, Table IV). This being the case, it is safe to assume that the soil below the 24-inches depth at each of the other sites (except perhaps Ortinola) was also waterlogged throughout the period when the corrosion tests were being made. The soil at Ortinola seems to be exceptionally well drained to considerable depth.

The low rate of corrosion in the 0-4 and 4-8 inch layers at San Louis indicates a waterlogged condition even near the soil surface at this clay site, but the same was not the case at Las Hermanas, another clay site, whose surface layers gave much higher values.*

Acidity —No general correlation between soil acidity and corrosiveness is indicated by the data, but the high values for rate of corrosion shown by the Las Hermanas upper layers (0-4 and 4-8 ins.) suggest that here acidity might have been the controlling factor. A supplementary experiment carried out later at this site, however, failed to confirm this, though the conditions admittedly were drier when the second experiment was performed. It was nevertheless found that the

*The degree of aeration during moist and wet conditions at the Las Hermanas site, as indicated by soil-gas analysis (*see* Part II, Tables V and VI, and Part III, Tables III and VI), may apparently be relatively high in the surface layer (*i.e.* the free air-space may approximate to 31 per cent. of the total pore-space), and higher even than that of the corresponding soil at River Estate. This may be attributed to a marked crumb structure in the Las Hermanas shallow surface soil.

surface layer of soil at the Las Hermanas site was heterogenous because of contamination with thrown-up drain soil, and various small samples exhibited different pH values when tested in the laboratory. It is doubtful therefore whether soil acidity is really the factor chiefly responsible for corrosion at this place.*

EXPERIMENT II

(*a*) *Objects* :—The objects of this experiment were three-fold namely,

(i) to trace the possible effect of fluctuating soil moisture content on soil corrosiveness,

(ii) to determine the rate of corrosion of iron spikes buried for different lengths of time,

(iii) to test the reliability of the corrosion method as a means of comparing soil aeration at adjacent individual cacao tree sites or within separate small blocks of trees.

(*b*) *Site and method* :—The site was River Estate, close to the place where soil-gas samples were collected during November, 1939, (*see* Part II, Table II), and not very far from the place where the first corrosion experiment was carried out. The surface of the land was slightly undulating owing to the fact that several mulch-trenches had been dug previously across the area, their soil covers not having sunk quite to the general level of the ground. Four rectangular blocks, each 8 × 3 feet in dimensions, designated (A), (B), (C) and (D), were marked out, two, (A) and (C), within the depressions, and two, (B) and (D), containing small mounds.

In each block, 36 prepared and weighed iron spikes were driven into the soil on 7th November, 1939, in random fashion. Nine (9) spikes were placed at each of the three depths, 0-4, 4-8 and 8-12 inches ; six (6) spikes were similarly placed at 24-28 inches, and three (3) at 36-40 inches depth. At each and every depth, three (3) of the spikes were left for a period of six weeks ; at each of the four depths, 0-4, 4-8, 8-12 and 24-28 inches, three (3) spikes were left for four weeks, and at each of the three depths, 0-4, 4-8 and 8-12 inches, three spikes were left for only two weeks, but they were replaced after the lapse of that period by an equal number of spikes which were left for a further two weeks, and after that by a third set of spikes which was allowed to remain for two weeks more. The spikes used in the second and third fortnightly periods were not inserted in the same holes as those occupied previously by spikes, but they were driven into the soil at adjacent spots. All spikes were cleaned and reweighed as soon after removal as possible.

(*c*) *Experimental results* :—These are recorded in Table III.

*The variation in acidity of the surface soil at the Las Hermanas site is also revealed by comparison between the results of other determinations made at different times (*see* for example Part III, Table V).

As in Experiment I, the individual values in the sets of three results, the means of which are given in the table, showed some variability. One set of three spikes, namely, that placed at the 0-4 inches depth and given six weeks' exposure, yielded abnormally high values (98, 96, 76 ; mean 90 cg. ; the expected mean value for this set would be about 56 cg.). The data have been fully tested statistically by the analysis of variance method, but the statistics are not here reproduced. The anomalous value mentioned above was omitted in the statistical calculations.

(*d*) *Conclusions* :—The following main conclusions emerge from the statistical consideration of the experimental data obtained in Experiment II.

(i) In the first fortnight, the average amount of corrosion at the 0-4 inches depth was relatively high ; at the 4-8 inches depth it was medium, and at the 8-12 inches depth it was relatively low for each of the four blocks. The mean values were, 21.2, 17.3 and 14.1 cg. of iron lost per spike. In the second fortnight, corrosion was relatively high at all three depths (*i.e.* 19.3, 17.8 and 20.3 cg.), but in the third fortnight, it was relatively low at the 0-4 inches depth, medium at 4-8 inches, and low again at 8-12 inches depth (*i.e.* 13.8, 16.4 and 12.6 cg.). These differences (which are all statistically significant) may be attributed to variable weather which was relatively wet during the first fortnight, drier during the second, and wet again during the third fortnight.*

(ii) The amount of corrosion was significantly different for the four blocks. The mean results are approximately numerically equal for Blocks (A), (B) and (C), but those for Block (D) are lower, both for depths and fortnights. There is perhaps more similarity between the results for Blocks (A) and (C), situated on depressions, than between those for Blocks (B) and (D), situated on small mounds, the former (contrary to expectation) being the larger. Block (D) lies nearest the road, and it is suspected that its soil suffered considerable compaction during the

* *Note.*—The mean seven days' moving average daily rainfall for the first and third fortnightly periods was 0.26 inch, and for the second, 0.12 inch. These changes were reflected in gross soil moisture contents, which were 29.4, 28.8 and 29.2 per cent. in the surface six-inch layer for the three fortnightly periods respectively, and 28.3, 27.8 and 27.0 per cent. in the less moist second six-inch layer. During the two wet spells, the percentage of the total pore-space volume of the surface soil that was occupied by air was only about 12 per cent., and during the drier spell, about 17 per cent. For the subsurface soil, the corresponding values for air content were irregular, *i.e.* 15, 17 and 19 per cent. Soil moisture and air contents for depths below 12 inches were not determined during the six weeks' run of this experiment although measurements made during the preceding weeks of September at the 24-30 inches depth showed an almost complete absence of soil-air. (F.H.)

Table III

Results of Corrosion Tests with Different Time Periods

Period of exposure to corrosion	Intervals (weeks)	(River Estate) 1	2	3	4	5	Means (Columns 1-3)
		0-4″	4-8″	8-12″	24-28″	36-40″	
		Loss in weight of one iron spike; means of three (centigrams)					
				Block (A)			
First fortnight	0-2	26	17	15	—	—	19
Second fortnight ...	2-4	18	20	20	—	—	19
Third fortnight	4-6	18	15	12	—	—	15
Four weeks	0-4	49	30	22	16	—	34
Six weeks	0-6	90 (56)	39	32	28	14	54 (42)
				Block (C)			
First fortnight	0-2	21	20	17	—	—	19
Second fortnight ...	2-4	21	22	21	—	—	21
Third fortnight	4-6	13	15	11	—	—	13
Four weeks	0-4	40	34	30	36 (28)	—	35
Six weeks	0-6	46	39	36	39	24	40
				Block (B)			
First fortnight	0-2	19	19	13	—	—	17
Second fortnight ...	2-4	21	17	24	—	—	21
Third fortnight	4-6	10	20	16	—	—	15
Four weeks	0-4	40	30	24	24	—	31
Six weeks	0-6	46	49	36	35	31	44
				Block (D)			
First fortnight	0-2	18	13	11	—	—	14
Second fortnight ...	2-4	17	13	16	—	—	15
Third fortnight	4-6	13	15	11	—	—	12
Four weeks	0-4	35	23	23	20	—	27
Six weeks	0-6	47	39	28	26	39	38
Means							
First fortnight	0-2	21	17	14	—	—	18
Second fortnight ...	2-4	19	18	20	—	—	19
Third fortnight	4-6	14	16	13	—	—	14
Means		18	17	16	—	—	17
Four weeks	0-4	41	29	25	(22)	—	32
Six weeks	0-6	(49)	41	33	32	27	(41)

operations of road making, or that it receives run-off water from the road, thus reducing its air content.

The fact that a significant difference was found between blocks suggests that differences in degree of soil aeration might be measurable by the corrosion of iron method, but much more experience would be necessary before the method could be recommended as a precise ecological instrument for comparing soil environments between individual tree sites or sites occupied by groups of trees, or even between fundamentally different types of soil.

(iii) The results for the 4-weeks' period (Nov. 7 to Dec. 5) agree on the whole with those for the separate fortnights, but those for the 6-weeks' period (Nov. 7 to Dec. 19) are appreciably less than the sum of the values for the three successive fortnightly periods, that is, the degree of corrosion of fresh pieces of iron is somewhat greater than that of pieces that have already been in contact with the soil for two or more weeks. The rate of corrosion does not decrease abruptly, so that it seems justifiable to accept the loss in weight during a fortnight's contact as a reliable measure of corrosion.

Summary

(1) A field method for estimating soil aeration by determining the rate of corrosion of iron spikes inserted into the soil at different depths is described, and the results obtained from its application to specific problems concerning cacao soils in Trinidad are presented and discussed statistically and ecologically. The soils were non-saline, non-calcareous, non-gypseous and (all but one) not exceptionally acidic.

(2) The method may not be applicable to soils having reaction values less than pH 4.3, because, under these conditions, corrosion is no longer a function mainly of aeration, but is partly controlled by acidity and the cathodic production of hydrogen gas.

(3) Evidence was adduced to prove that, during wet spells, the degree of soil aeration decreases markedly with depth in these cacao soils.

(4) Fresh clean iron spikes were found to corrode more rapidly than spikes that already had been allowed to corrode for a fortnight or more, and a fortnight period of contact is recommended as suitable for ecological investigations.

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THE COTTONS OF JAMAICA

BY

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The flora of Jamaica includes a variable group of cottons belonging to the cultivated species of the New World. Numerous species have been described by Watt (1907 and 1927) and Fawcett and Rendle (1926), but no study has been made of them in the light of recent changes in the taxonomy of *Gossypium* (Harland 1938 and 1940, Hutchinson 1939). The following account of their classification, variability and ecology, is presented in view of their importance in studies of the geographical distribution of New World species.

The cultivated New World cottons fall into four groups: 1. The South American *G. barbadense*, with its rather poorly defined var. *braziliense* (kidney cotton); 2. *G. hirsutum*, the Upland cotton of the Central and North America; 3. *G. hirsutum* var. *punctatum*,* the indigenous perennial cotton of the coasts and islands of the Gulf of Mexico; and 4. *G. hirsutum* var. *marie-galante**, the tropical cotton of northern South America and the coasts and islands of the Caribbean Sea.

The perennial cottons of the coasts and islands of the Gulf of Mexico from British Honduras to Florida and the Bahamas are *punctatums*. A *punctatum* strain (*G. ekmanianum* Wittmack 1928) occurs wild in Haiti (Barakona province, Wittmack) and Mr. R. A. Silow of the Cotton Research Station, Trinidad, identified as this variety a specimen in J. T. Boig's collection, from Pinar del Rio province, Cuba, where it is said to have been cultivated. The wild cottons of the Cayman Islands also belong to var. *punc atum*. All living material known from the Lesser Antilles and the coasts and islands of the Spanish Main is either *marie-galante* or *barbadense*. Records of *punctatum* cottons from the south Caribbean can confidently be ascribed to errors in identification of herbarium material. Porto Rican tree cottons collected by Dr. L. F. Martorell for the author were all *marie-galante*. *Marie-galante* was collected near Havana, Cuba, by R. A. Silow, and Harland (1938) records that it is cultivated in Haiti.

It will be seen that Jamaica lies on the margin of the areas of distribution of *punctatum* and *marie-galante* and its cottons are therefore of considerable taxonomic interest. An opportunity of making a fresh study of them was afforded by a visit to Jamaica in May and June, 1942. The *Gossypium* sheets in the herbarium at Hope were examined, but they are in very bad condition, and are quite worthless either for identification or for checking the classification of other workers. The following notes are therefore based entirely on living material, observed either in nature in Jamaica or in culture, from Jamaican seed, at the Cotton Research Station, Trinidad.

To facilitate the identification of the cottons of Jamaica and neighbouring countries, a key is given below. With living material no difficulty should be encountered in using it, but the differences between varieties of *G. hirsutum* are not always easy to see in herbarium material.

a. Staminal column long; anther filaments short, all about the same length; anthers closely packed—b
  b. Bolls usually less than 6 cm. long, broadest near the base—*G. barbadense*.
  bb. Bolls usually more than 6 cm. long, broadest about the middle—*G. barbadense* var. *braziliense*.

G. hirsutum var. *punctatum* = Harland's *G. punctatum*.

G. hirsutum var. *marie-galante* = Harland's *G. purpurascens*.

Evidence in support of this nomenclature will be published elsewhere.

aa. Staminal column short; anther filaments longer above than below; anthers openly spaced—c

c. Bracteole teeth 6-14 (usually about 10); anthers rather sparsely and irregularly arranged—d

d. Annual sub-shrubs with large leaves and widely expanding flowers—*G. hirsutum*.

dd. Perennial, much branched shrubs with small leaves; flowers forming a narrow tube—*G. hirsutum* var. *punctatum*.

cc. Perennial shrubs; bracteole teeth 3-11 (usually about 6); anthers very many, and regularly arranged on long filaments—*G. hirsutum* var. *marie-galante*.

True Upland cottons have been introduced into Jamaica for commercial trials, but have never become established. It is probable that the Jamaican specimens referred to *G. hirsutum* by Watt (1907) were the result of such introductions. I saw a very old, much ratooned plot of var. *punctatum* on a property near Black River. It was grown from seed sent many years ago from India, where var. *punctatum* is known to have become established. Nothing else was seen approaching var. *punctatum*.

The *marie-galante* cottons show every sign of being indigenous. Small bolled, small seeded types with very inferior lint are to be found growing wild in xerophytic scrub lands, and these are connected by an extensive and variable series with the comparatively large bolled, long linted forms found growing in association with man in house yards and by road sides. The range of variation observed is summarised below :—

Habit	Perennial. Branching very variable. In some types there are few or no vegetative branches, and only short fruiting branches on the upper part of the stem. In others the vegetative branches develop early and profusely, and soon equal the main stem, giving a rounded shrub. Others again develop a number of branches low down, but the main stem maintains its dominance, giving the shrub a pyramidal outline, and yet others only develop branches 18 ins. or more above the ground level, forming a small tree with a short but definite trunk. Besides variation in branching, there are large differences in rate of growth, some types remaining comparatively low growing shrubs and others growing rapidly to 8 ft. to 10 ft. or even more.
Hairiness	Practically glabrous, sparsely hairy, hairy, or softly tomentose.
Leaf shape	Of 23 plants recorded there were: 1 deeply laciniated: 8 laciniated: 8 Sea Island type broad leaf: 6 Upland type broad leaf. Laciniated leaved types were only seen in the dry southern plain.
Flowers	Yellow or cream corolla; yellow or cream pollen; full, weak, or no spot.
Bolls	Very variable in size; usually rounded, with a prominent beak, sometimes long, narrow and tapering; surface usually smooth, sometimes pitted.
Seeds	Usually fuzzy, sometimes tufted; fuzz green, brown or white.
Lint	Usually white, sometimes dingy grey. Often short and coarse and almost worthless. Sometimes long and fine or long and rather coarse. Generally inferior to the cultivated *marie-galante* of the Grenadines.

The following names have been applied to this variety in the literature on Jamaican cottons:

Species and variety	Reference
G. hirsutum var. *religiosa*	Watt (1907)
G. punctatum var. *jamaica* = *G. jamaicense* Macf.	Watt (1907)
G. harrisii	Watt (1927)
G. marie-galante	Watt (1927)
G. arboreum	Fawcett & Rendle (1926)
G. hirsutum	Fawcett & Rendle (1926)
G. purpurascens	Fawcett & Rendle (1926)

Marie-galante cottons are to be found in most parts of the island at low altitudes. In the mountains they are rare or absent, and they are not common in the wetter and more mesophytic districts, such as St. Mary and Portland, even at low altitudes. They are commonest, and most variable, in the dry southern plains in the parishes of St. Catherine, Clarendon and St. Elizabeth. In Vere, one of the driest and most xerophytic districts in Clarendon, small colonies of *marie-galante* cottons were found in secondary scrub. There were from about half a dozen to a score of plants in a colony, quite obviously spontaneous. They were small (not more than 3 ft. to 4 ft. high) and almost without vegetative branches, but their habit was undoubtedly chiefly determined by the severity of their environment. They had the small bolls, small seeds, and scant, coarse, short, grey lint of the truly wild form, and it can be said with some confidence that they represent the primitive wild form of *marie-galante* cotton. In the islands of the Lesser Antilles where such wild forms have been recorded from xerophytic bush lands, there is usually a fairly clear distinction* between the small bolled, small seeded, wild form with worthless lint, and the larger bolled, larger seeded "back yard" form with comparatively good lint. In Jamaica the distinction is not so sharp. Among the "back yard" types, small bolls are common and the average quality of the lint is low and its variability great, so that there is a complete range from the wild type of Vere to the better "back yard" cottons that have been considerably improved by man.

If pest hazards could be reduced, *marie-galante* cottons would offer attractive prospects for the establishment of commercial cotton growing.

*This distinction was brought to my notice by H. E. Box in Antigua.

They are well adapted by their drought resistance and perennial habit to withstand the uncertain and erratic rainfall conditions in southern Jamaica, and there is in that area a considerable peasantry in need of a cash crop, and ample land on which it could be grown.

The *barbadense* cottons of Jamaica are the relics of successive attempts to establish commercial cotton growing. Kidney cottons (the *G. lapideum* of Tussac 1818 and the *G. braziliense* of Macfadyen 1837) were early introductions (Sloane, quoted by Watt 1907) and both types distinguished by Lewton (1920)—the long narrow kidney of the Guianas and the short broad kidney of Brazil are still to be found, though the former is much the commoner. At a later date the free seeded form of the kidney cotton—Cauto, the *G. braziliense* var. *apospermum* of Sprague (1914)—was introduced from Cuba, and became established. The annual Sea Island cotton was also introduced and grown for some years, but it was not a commercial success. The chief cause of failure was pest damage, but an important subsidiary factor was the contamination of the seed supply with Cauto × Sea Island hybrids (*J. Jamaica Agric. Soc.* 1916). Some of the perennial *barbadenses* now to be found which lack the kidney characteristics are probably descendants of those hybrids.

The following species and varieties mentioned in the literature on Jamaica belong to *G. barbadense* and its var. *braziliense* :

Species and variety	Reference
G. barbadense	
G. peruvianum	Watt (1907), Fawcett & Rendle (1926)
G. vitifolium	Watt (1907)
G. barbadense	Fawcett & Rendle (1926)
G. barbadense var. *braziliense*	
G. braziliense	Watt (1907)
G. pedatum = *G. braziliense* var. *apospermum*	Watt (1927)
G. lapideum	Fawcett & Rendle (1926)

G. barbadense is in general more mesophytic than the *marie-galante* cottons, and it has only become established in the more mesophytic areas. On the southern side of the island it was only collected in inland localities where conditions of moisture and shelter were such that bananas and coffee grew fairly well. On the north, it is fairly common in St. Mary and Portland, which are comparatively mild and moist.

Summary

1. The indigenous cotton of Jamaica is *G. hirsutum* var. *marie-galante*. It is highly variable and exists in the wild state as well as in association with man in house yards and on vacant lots and roadsides. Ecologically, it is the cotton of the xerophytic scrub lands, and it is commonest and most variable in the dry southern plains.

2. *G. hirsutum*, the Upland cotton is only known from Jamaica from specimens recorded by Watt (1907). A single plot of *G. hirsutum* var. *punctatum* was found near Black River, but it is known to have been grown from imported seed.

3. Perennial and annual (Sea Island) forms of *G. barbadense* and *G. barbadense* var. *braziliense* have been introduced from time to time in attempts to establish commercial cultivations. The perennial forms have become established in the moister and more mesophytic areas, such as St. Mary and Portland.

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ROOT-ROT OF COTTON AS INFLUENCED BY INTER-CROPPING

Experiments conducted in Khanewal and in Lyallpur in the Punjab on the effect of growing mixed crops or inter-cropping in cotton are reported to have led to very striking results in reducing the incidence of root-rot in the cotton crop (R. S. Vasudeva, *Ind. Jour. Agr. Sc.*, 11, Pt. 6). The cotton experimented with was the variety Mollisoni (*G. indicum*) and the crops grown as mixture were Sorghum, *Setaria italica*, *Phaseolus aconitifolius* and *Panicum colonum*. The sowing was all on land known to be badly infected and during the season most favourable to the spread of the disease. The cotton was sown in rows 2½ feet apart and in between every two rows the mixed crop was sown in rows or broadcasted. The mixed crops were allowed to grow for different periods up to a maximum of about three months. The percentage mortality due to the disease was not more than 5 as long as the sorghum remained on the land and after it was removed did not go higher than 22 ; in the controls the mortality was about 68 per cent. The other crops used also markedly reduced the incidence of disease, the phaseolus being remarkable in this respect ; while the control plots of pure cotton showed a mortality of 52.5 per cent. the mixed phaseolus plot showed only from 0.5 to 1 per cent. Experiments with American cotton also gave similar results. It is also noted that the yield of cotton was higher in the mixed crops than in the pure cotton crops.—(*Current Science*, 11, No. 4, 1942).

NOTES ON SOME DISEASES OF FIELD CROPS, VEGETABLES AND FRUITS AT THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

BY

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V. FRUITS AND VEGETABLES

Bananas (*Musa* spp.) *

Mycosphaerella musicola Leach (*Cercospora musae* Zimm.) Leaf-spot, Sigatoka Disease

The symptoms of this disease are too well-known to merit description. It is common and severe on commercial and experimental varieties. Those interested in the control of this disease are recommended to read the recent work of R. Leach (14 and 15) in Jamaica.

Fusarium cubense Smith Panama Disease

This disease is common at the College on the susceptible Gros Michel and Sucrier varieties.

The I.C.2 banana, bred at the Imperial College, is resistant to both these diseases.

Grapefruit, Oranges and Limes (*Citrus* spp.) *

Limes are commonly attacked by *Gloeosporium limetticolum* Clausen (Withertip disease) and sour oranges and other varieties of *Citrus* by *Elsinoe fawcetti* Jenkins (Scab). Gummosis caused by *Phytophthora parasitica* Dastur occurs sporadically in wet weather. Greasy spot or black melanose, a disease of unknown origin which produces dark greasy-looking spots on the older leaves of grapefruit is common, but appears to do little damage. The position with regard to Red Root Disease of limes was summarised by the author (6) in 1938. For notes on other diseases and fruit-rots of citrus in Trinidad the following articles are recommended (1, 2, 5, 8, 13).

Papaw (*Carica papaya* Linn.) *

1. Mosaic Disease.

A serious disease of papaws characterised by a yellowing and death of the crown of the tree, presumed to be of virus origin, is common and severe. Diseased trees should either be uprooted and destroyed or cut back some feet below the crown and not more than three axillary buds allowed to develop. The top of the stump should either be protected with an empty tin or filled with concrete to prevent the accumulation of rainwater which will not only rot the stump but will also provide a breeding place for mosquitoes. A summary of our knowledge of this disease was published recently (7).

2. Asperisporium caricae (Speg) Maublanc Leaf-spot

Causes numerous small spots on the older leaves. These are brown above and blackish below with masses of conidiophores and conidia. Little or no damage is caused.

3. Colletotrichum gloeosporioides Penz. Anthracnose

Sunken, blackish, watersoaked lesions covered with the acervuli of this fungus occur commonly on ripening fruit and are responsible for considerable loss and wastage.

Mangoes and avocado pears have no serious diseases, but like the papaw suffer severely from fruit rots of which the commonest is anthracnose (*Colletotrichum gloeosporioides*). Mango anthracnose has been more fully discussed by McKee (18) and by the author (4) in 1938 and 1940.

For a fuller account of the storage rots of tropical fruits and vegetables in Trinidad, Wardlaw's (24) 1937 memoir is recommended.

Carrots (*Daucus carota* Linn.) *

During wet weather both young and old leaves are often blackened and destroyed by a disease of unknown origin. The spores of a species of *Alternaria* are constantly associated with the diseased lesions but have so far not been proved to be the cause of the disease. The disease is common, though it only occurs in the wet season, and can be serious, having a considerable retarding effect on young carrots. Clean weeding, manuring, and wider spacing during the wet season should help in its control.

Carrots are sometimes destroyed in the ground by bacteria of the *Bacterium carotovorum* group.

Cabbage, Cauliflower, Chinese Cabbage, Mustard, &c. (*Brassica* spp.)*

1. Alternaria brassicae (Berk.) Bolle Leaf-spot

The typical large brown leaf-spots showing concentric zonation are found on various *Brassica* spp. They are never serious, appearing only on the older leaves. An unidentified brown rot of the heads of cauliflower, also possibly caused by this fungus, occurs occasionally in wet weather.

2. Cercospora bloxami Leaf-spot

This fungus often attacks the Chinese cabbage (*Brassica chinensis* Linn.) and in October, 1942 it was sufficiently severe on the variety Patchoi to render it useless. The lesions are small and round, light coloured at first, then black, and coalesce to cause extensive leaf damage.

Cucumber, Melon, Pumpkin, &c. (Fam. *Cucurbitaceae*) *

Pumpkins and water melons are seldom seriously attacked, but cucumbers and musk melons often suffer severely from one or more of the following diseases. No attempt has been made to control them, but a sulphur dust should prove effective

against the mildews in dry weather. Plants growing vigorously will often produce a crop before they are seriously attacked.

1. *Oidium* sp. Mildew

A powdery mildew occurring on both sides of the leaves as a thin whitish weft of mycelium often occurs in dry weather but does little damage.

2. *Pseudoperonospora cubensis* (B. and C.) Clinton Downy Mildew

Often attacks cucumbers causing large irregular straw-coloured areas on the leaves. Considerable destruction of foliage and loss of crop may result.

3. *Rhagadolobium cucurbitacearum* Leaf-spot

The small black spots of this fungus are occasionally very numerous on the older leaves, but are of little practical importance.

4. *Cercospora* sp. Leaf-spot

An unidentified species, apparently causing little damage, was recorded in 1940.

5. *Bacterium aroideae* Townsend Soft-rot

A bacterial soft rot, starting as small water-soaked areas, often causes serious damage in wet weather. Cucumbers in contact with moist soil are most commonly affected, the staking of the plants might prove a satisfactory means of control.

Okra (*Hibiscus esculentus* **Linn.**)*

1. *Cercospora hibisci* Tr. and E. Leaf-spot

Causes irregular black lesions on the leaves. Conidia are visible as whitish patches on the undersides of these lesions. Leaves are occasionally almost entirely blackened, and the disease is common on all the older leaves but appears to cause little damage.

2. An unidentified downy mildew was recorded in May 1941.

Sweet Pepper (*Capsicum annuum* **Linn.**)

1. *Cercospora capsici* H. and W. Leaf-spot

Causes dark brown patches on the leaves often uniting to form large areas of dead tissue. The severity of the attack varies, but damage is seldom serious.

2. *Colletotrichum gloeosporioides* Penz. Anthracnose.

In July 1942 sunken lesions up to an inch in diameter on the fruit yielded a species of *Colletotrichum* in culture. Diseased fruits were especially common on plants attacked by mosaic disease.

3. *Mosaic disease* Virus

Causes severe yellowing, rolling and abscission of many of the leaves and shoots. Plants are seriously damaged and stop bearing. This is the most serious disease of sweet peppers on the College farm and is at present under investigation along with other virus diseases of the Solanaceae and Leguminosae. It is hoped that the results of this work will be published in this journal in about six months time.

Tomato (*Lycopersicon esculentum* **Mill.**)

Tomatoes are attacked by a large number of diseases, many of which can prove serious, especially in wet weather. For various reasons it appears to be impossible, except under artificial conditions, to raise a crop of tomatoes in St. Augustine during the wet weather, but good crops may be obtained during the dry weather. Some of the reasons for failures in the wet season are discussed below, but fuller accounts of tomato diseases and fruit rots will be found elsewhere (9, 11, 21).

1. *Septoria lycopersici* Speg. Leaf-spot

Recorded in January, 1940, but not serious.

2. *Phoma destructiva* (Plowr.) Jamieson Leaf-spot

This disease is usually common, causing abundant dark brown leaf lesions, often resulting in a serious loss of foliage, and during the 1938 wet season it caused the destruction of an entire plot of tomatoes on the farm. It is also one of the worst rots of ripening fruit.

3. *Cladosporium fulvum* Cke. Leaf-mould

Another serious leaf disease which may cause severe damage and even complete failure of the crop during wet weather. On the upper surface the lesions are yellowish or pale green while on the underside of the leaves they appear greyish or brownish and velvety with the conidia and conidiophores of the fungus. Little is known about the control of this disease locally, as when it is serious complete failure of the crop is probable for other reasons.

4. Wilt

Wilts caused by a variety of organisms among which are included *Pythium* sp., *Sclerotium rolfsii* Sacc., *Fusarium lycopersici* Sacc., and *Bacterium solanacearum* Smith occur commonly in wet weather. Affected plants stop growing, the leaves turn yellow and wilt and finally the plants die. On splitting the stem the vascular tissue will be found to be discoloured. In wet weather control appears to be impossible and soil once infected will remain so for years. In dry weather, with proper control of watering, good crops can be raised in spite of wilts.

5. 'Wet Weather Disease'

This disease or set of symptoms, was recorded in October and November, 1941 during very wet weather, but this is by no means the first record of it. Plants appear stunted, the leaves large and fleshy, axillary buds proliferate, and the flowers fail to set fruit and drop off. This disease usually results in a complete loss of crop during wet weather, but plants may recover when the weather improves. It is thought to be a physiological disease, and to be associated with heavy rain, high atmospheric humidity and a waterlogged soil.

6. Mosaic Virus

A mild mosaic is frequently met with, but the extent of the damage it causes is at present unknown. It is possible that other virus diseases occur.

7. Fruit-rots

Fruit-rots in storage are dealt with elsewhere (9, 11, 21). In the field 'Bubbly fruit-rot' (*Bacterium aroideae* Towns.) is frequently met with in wet weather and occasionally in dry weather. Tomatoes attacked by this disease are transformed into an evil-smelling liquid containing bubbles of gas.

'Blossom-end rot' causing a dark brown sunken area around the 'blossom-end' of the fruit occurs commonly in dry weather. It is a physiological disease brought on by exposure to drying winds and irregular watering, but is difficult to control. Experience indicates that inattention to watering, allowing the plants to begin to wilt *even once* during dry weather may bring on this disease. Differences in varietal susceptibility have been noted by Young (25) in the United States, Marglobe being among the varieties which showed resistance.

Beetroot (*Beta vulgaris* **Linn.**)

Cercospora beticola Sacc. Leaf-spot

Causes many brown spots, each surrounded by a red ring, on the leaves. During wet weather, when it is frequently abundant, it can cause serious damage, and, by destroying the leaves, prevent the proper development of the roots.

Celery (*Apium graveolens* **Linn.**)

Cercospora apii Fr. Leaf-spot

Causes numerous irregular light brown spots and a general yellowing of the leaves and stems. Damage may be severe enough to ruin the crop during wet weather, and for this and other reasons, it is better to confine celery growing to the dry season.

Jerusalem artichokes (*Helianthus tuberosus* **Linn.**)

Sclerotium rolfsii Sacc. Soft Rot of tubers

As they ripen, artichokes are often destroyed by this fungus which is easily identified by the vigorous white mycelium with sclerotia resembling mustard seed. This mycelium covers the tubers and spreads over the ground in the neighbourhood of the diseased plants. The soil is likely to become contaminated with the sclerotia, and therefore artichokes should be grown in rotation with other vegetables, and patches of soil where the disease has been severe should be avoided. Diseased material should be destroyed and never put into a compost heap.

VI.—MISCELLANEOUS CROPS

Sesamum (*Sesamum orientale* **Linn.**)

Cercospora sesami Zimm. Leaf-spot

Causes abundant small lesions on both young and old leaves, stems and even seed-pods. The lesions are circular with a dark border and a light centre which finally falls out to leave a 'shot-hole'. Although regularly present and very common, this disease causes no appreciable damage.

Castor Oil (*Ricinus communis* **Linn.**)

Cercospora ricinella (Sacc. and Berl.) Speg. Leaf-spot

Forms dark brown irregular lesions up to half an inch across which are particularly common on old and moribund leaves. Damage is not serious.

Cotton (*Gossypium* spp.)

Many diseases are recorded both from the Empire Cotton Research Station and from the Imperial College, but few are of any importance. It should be noted that cotton is not grown on a commercial scale in Trinidad. The following may usually be found, but not to any serious extent.

1. *Glomerella* (*Colletotrichum*) *gossypii* (South) Edg. Anthracnose

Causes damage and distortion to the leaves, stems and bolls of many varieties and is probably the most troublesome disease of cotton in Trinidad. Control would probably entail regular spraying with a copper fungicide and has so far not been considered worth while.

2. *Bacterium malvacearum* Smith Angular leaf-spot, Black Arm

In Trinidad the black arm phase of the disease, when branches and young plants are destroyed, is seldom found. Angular leaf-spot, characterised by numerous small water-soaked lesions tending to lie along the main veins of the leaves and to coalesce, is common on certain varieties.

3. *Ramularia areola* Atk. Mildew

Occurs commonly in wet weather as white patches on both sides of the leaves but causes little damage. A second cotton mildew caused by *Ovulariopsis gossypii* Wakefield is much rarer.

4. *Cerotelium* (*Kuehneola*) *gossypii* Arthur Rust

Always common on the older leaves of perennial cottons, but seldom causing appreciable harm to the plants.

5. *Alternaria macrospora* Zimm. Leaf-spot

Recorded in January, 1941 and again in 1942 and probably always present on a small scale. It causes large concentrically zoned leaf-spots, which as they become older, develop a dark border and a light brown centre. Conidia are produced abundantly on both sides of the lesions.

6. *Nematospora gossypii* Ashby and Nowell Internal Boll Disease

Isolated from the bolls of upland cotton in February, 1941. This and other internal boll disease fungi probably occur regularly, but the extent of the damage caused is difficult to estimate. This fungus has also been isolated from tomatoes showing internal discolouration.

7. Root-rots, usually caused by members of the genus *Rhizoctonia* occur sporadically in wet weather.

Tobacco (*Nicotiana tabacum* **Linn.**)

1. Cercospora nicotianae E. and E. Leaf-spot

Causes small, circular light brown spots about a quarter of an inch in diameter which are usually confined to the lower leaves and are therefore of little importance. Almost always present on tobacco grown at the College, but seldom serious enough to be worth attempting to control. Wider spacing, and the removal of the lower leaves with correspondingly higher topping has given satisfactory results both in Trinidad and in Nyasaland.

2. Nicotiana Virus 1. Mosaic

This virus, the commonest of the tobacco mosaics, causes a light and dark green mottling of the leaves together with some blistering. In recent years tobacco crops at the College farm have been regularly attacked and as much as thirty per cent. of the plants in a field have been affected. The damage is difficult to assess but may be quite severe. This disease is at present under investigation.

3. Phytophthora parasitica Dastur Black Shank

Isolated plants suffering from this disease are found occasionally.

VII.—GENERAL SUBJECTS

1. Eelworm disease, Root-knot

The eelworm *Heterodera marioni* (Cornu) Goodey is very common on the College farm and in gardens in the vicinity. It causes knots and galls on the roots and can cause serious damage to vegetable crops such as tomatoes, lettuces, beans, carrots, &c. Owing to root damage the plants grow more slowly and are reduced in size, only seldom being killed outright. The cropping power of tomatoes and beans may be considerably reduced. Control is difficult, but possible where soil can be sterilized by heat or broken up and allowed to dry out during the dry season. Good cultivation and manuring, in order to ensure rapid growth will minimise the effects of the disease.

2. Damping-off Diseases

Diseases of this type, caused by species of *Phytophthora, Pythium* and *Rhizoctonia* are very common and often troublesome in seed beds and boxes. Many kinds of vegetable seedlings including cabbage, cauliflower, beetroot, tomato and especially tobacco are attacked. The seedlings are attacked at or near ground level and rapidly fall over and die.

Methods of controlling 'damping-off' include soil sterilization, the use of fungicides, and practical precautions designed to avoid setting up the hot damp conditions which favour the disease.

Soil sterilization by heat is sometimes possible on a small scale. Tobacco seed beds are sometimes 'burnt-off' by lighting a brushwood fire on the bed before sowing, and sufficient soil to fill seed-boxes for garden purposes can be heated on an iron plate over a brushwood fire. Sterilization by chemicals such as formalin or sulphuric acid is more difficult and not often attempted.

Easily the best fungicide for controlling damping-off is Cheshunt Compound. This is made by powdering and mixing 2 ozs. of Copper sulphate (bluestone) with 11 ozs. of Ammonium carbonate and allowing the mixture to react for 24 hours. One ounce of the mixture is then dissolved in 2 gals. of water, and used for watering the seed-beds or boxes. If Cheshunt Compound is to be used it must be used *from the start,* it is too late to begin to use it when damping-off appears in the seed-bed.

Much can also be done by the proper control of watering and by not overcrowding plants in boxes. Warm damp conditions are conducive to damping-off, and if plants are more widely spaced and given a good watering as infrequently as possible, rather than the frequent light waterings to which seedling are usually subjected, and if the water is run on to the soil and not sprayed on to the leaves of the plants, much of the trouble can be avoided.

An excellent way of watering boxes, baskets and clay pots is by standing them in shallow water until the soil has absorbed sufficient moisture. Plants watered in this way will seldom suffer from damping-off.

3. Wilt Diseases

Diseases of this type are common on the College farm and in St. Augustine generally. Plants affected include tomatoes, Sunn hemp, pigeon peas, jute (*Corchorus olitorius* Linn.) roselle (*Hibiscus sabdariffa* Linn.) and sesamum. Plants are attacked at any age and are first observed to wilt in the middle of a hot day. As the disease spreads, growth ceases, wilting becomes permanent with no recovery at night, the leaves turn yellow and drop off, and the plant dies. If the stem of a diseased plant is split open a brown discoloration of the vascular bundles will be noticed spreading upwards from ground level and sometimes reaching the mid-ribs of the leaves. It also extends downwards into the root system. A microscopic examination of the diseased tissues will show that the vascular bundles are full of fungous mycelium or bacteria. The organisms most commonly concerned are *Fusarium vasinfectum* Atk., *Bacterium solanacearum* Smith, and *Fusarium lycopersici* Sacc. *Phytophthora parasitica* Dastur may cause similar symptoms on tobacco, and *Sclerotium rolfsii* Sacc., attacks many plants but may easily be distinguished from the true wilt-disease-producing fungi by its profuse external white mycelium and masses of brown sclerotia.

Diseases of this type are very difficult to control, and once soil has become heavily infected it may remain so for many years. Wet weather is undoubtedly a predisposing factor in some instances, such as tomato wilt. This disease is prevalent in wet weather but causes little trouble during the dry season, provided that reasonable care is taken with watering. Other crops such as Sunn hemp and roselle were so badly attacked whenever they were planted that their cultivation at the College became almost impossible. Sunn

hemp could indeed be used as a green manure as plants did not usually wilt until they had reached a fair size, but it became very difficult to raise a crop for seed for the next planting. In 1938 a new 'immune' strain of Sunn hemp was introduced from India. This strain, although obviously highly resistant to wilt, did not at first appear very promising as it set little seed. During the last four years however it has either become acclimatised or hybridised with local strains and is proving very satisfactory.

4. *Cercospora* leaf-spots

The genus *Cercospora* is very well represented in Trinidad and is responsible for leaf-spots of many field crops and vegetables. During 1933 and 1934, W. F. Steven, a post-graduate plant pathologist at the College, recorded over fifty species of which twenty-nine were new records for the Colony. They are found on many legumes, on maize, sorghum and grasses, on tobacco, bananas, celery, beetroot, cotton, cassava, yam, pigeon pea and on many other plants. The spots are nearly always small and circular and vary in colour from light brown to black. Sometimes the centre falls out to leave a 'shot-hole'. Each spot is the result of a separate infection, and when they become numerous and coalesce severe leaf damage may result. This is well illustrated by *Cercospora musae*, the banana leaf-spot. The spores, which are typically long and filiform are produced mainly on the under-side of the lesions and are widely distributed through the air. Some species occur commonly in dry weather. This does not mean that they are particularly adapted to dry conditions as they also occur during wet weather, but merely that the heavy dews of the dry season are sufficient for infection, and the absence of heavy showers which are liable to carry away many spores, favours their rapid dispersal.

In most instances control would only be possible by means of protective copper sprays, and would only be worth while in exceptional instances and for highly profitable crops, such as bananas or tobacco. Certain crops like celery are severely attacked at one season but can be grown successfully at another. It is usually best to recognise this fact and not to try to grow the crop during the unfavourable season, although a 'wet' dry season or a 'dry' wet season may prove unexpectedly favourable and a valuable out of season crop may be obtained. The vast majority of species, however, occur commonly only on the older leaves and thus cause little damage and require no special control measures.

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CHEMICAL NOTES

(Compiled by the College Department of Chemistry and Soil Science)

Potash Content of Coconut Husks and Husk Ash

In the *Tropical Agriculturist* (Vol. 97, No. 2), Salgado and Chinnarasa have shown that the potash content of 1,000 coconut husks averages 3.47 lb. When the husks are taken from palms growing in soil to which potassic fertilizer has been applied (3 lb. of muriate of potash per palm) it was found that the average potash content of 1,000 husks was 5.67 lb. thus showing that the potash content of the husks was directly proportional to the potash status of the soil.

A wide range of variation in potash content of husks was found from both husks from palms grown in unmanured and manured soils. It was also found that the potash content of husks correlated closely with the potash content of the corresponding husk ash.

As potash salts are likely to be lost by volatilization at high temperatures, the burning of husks to produce potash manure is best conducted in shallow pits about two feet deep where burning will be comparatively slow. Burned in this manner the ash is obtained in a fine dry powder with a high potash content.—(*Fiji Agricultural Journal*, XIII, No. 2, 1942.)

* * *

Dry Farming Investigations in India

Dry-farming investigations in Madras suggest that the effectiveness of different cultural treatments in the conservation of rain water depends largely upon the initial moisture content of the soil and the distribution of rainfall. The plots receiving the larger number of intercultivations showed the higher moisture at harvest time. No definite conclusion could be drawn with regard to the optimum number of intercultivations. There was a general similarity in the fluctuations of nitrate nitrogen and of soil moisture, accumulation of nitrates taking place during the rainy season. Intercultivations has not been found to increase nitrification. Variations in total nitrogen during crop growth were small.—(*Soils and Fertilizers*, V., No. 4, 1942.)

* * *

Soil Salinity and Sugar Cane

Good yields of cane and sugar can be obtained on fields containing 1,200-1,900 p.p.m. of salt in the top 36 inches of soil, up to 54 tons of cane and 5 tons of sugar per acre. In saline areas and particularly where the irrigation water is saline, fall planting is preferable to spring planting. The effect of the salinity varies with the soil texture. Salinity will affect some varieties more than others, *e.g.*, B.H.10/12 is more susceptible than P.O.J.2727 and Co. 281 or 213. A diminution of purity with increasing salinity appears to be indicated while the effect on the cane/sugar ratio is more uncertain. Further work, following the fluctuations of soil content on different soils throughout the whole period of growth of sugar cane is necessary before any definite figures can be ascertained to show the amount of salinity that will affect appreciably the growth of cane and the quality of the juices.—(W. R. S. Ladell.—(*The Jamaican Association of Sugar Technologists, Quarterly*; 1942, Vol. V, No. 4, p. 2.)

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Conversion of Coconut Oil Into a Solid Crystalline Mass

While engaged in the study of thermal decomposition of coconut oil, J. Banzon (*Philippine Agriculturist*, XXVI, No. 5, p. 399) observed that a particular catalyst had the unique property of converting coconut oil into a crystalline solid mass.

The process is the simple distillation of coconut oil with ferric oxide or finely divided iron. The distillate thus obtained is dark-yellowish with a bluish fluorescence. On cooling it sets to a crystalline greenish-yellowish mass, which may be purified by repeated washings with methylated spirits.

The purified product is a light, white, crystalline powder, tasteless and with a faint odour similar to stearic acid. It melts sharply at 55°C to a clear transparent, colourless liquid, and solidifies to a hard, rather brittle, crystalline solid. Owing to its close resemblance to paraffin, this solid may possibly be used interchangeably with the latter, as, for example, in candle-making.—(*Fiji Agricultural Journal*, XIII, No. 2, 1942.)

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Urea

Urea, a synthetic chemical, which was not even manufactured in the United States of America until recent years, to-day is helping to make an important farm-grown product more useful for both war and peacetime purposes, for it is being widely used to inhibit splitting of lumber during seasoning or drying, and to treat wood so that it may be bent and shaped for specific war uses. The United States Navy is using thousands of feet of treated lumber for decks, ribs, frames, and other structural parts of ships. The United States Army is purchasing treated lumber, planks and rails on Army pontoons used for bridges. Without urea, it would have been almost impossible for the lumber industry to supply all the lumber requested for Army pontoons. Some mills that tried to dry this material without urea experienced seasoning de-grades of 40 to 60 per cent. of the stock dried, and in addition, jammed their drying kilns for an unreasonably long time. These seasoning difficulties were largely solved by the use of urea, and kiln de-grades of this important farm-grown crop of lumber were reduced to around 3 per cent. —(*Indus. Eng. Chem., News Edit.*, 1942, Vol. 20, p. 1134.)